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(54) **Image enhancement method and circuit.**

(57) The present invention relates to an image enhancement method and circuit adaptive to a scene which adaptively controls the brightness and contrast of a video input signal according to its average brightness level. The circuit comprises calculating means (20) for calculating the average brightness level during a predetermined period with respect to a video signal to be input through an input terminal; and controlling means (30) for controlling the brightness and contrast of the video input signal according to brightness correction characteristics corresponding to the calculated average brightness level, in which the range of the average brightness level in the video input signal is divided into a plurality of areas, and a plurality of input-output characteristic curves are provided so that the brightness and contrast of the video input signal is differently corrected for respective areas. The present invention has effects that naturally display even a dimly-lit picture by preventing an abrupt variation in brightness, and provide advanced pictures in brightness and contrast by adjusting only the contrast at a particular nAPL range.

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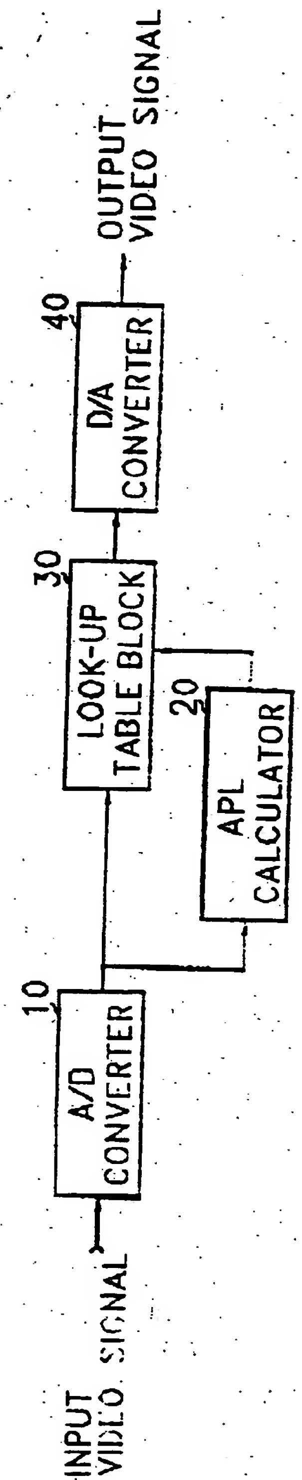
FIG. 5


INPUT VIDEO SIGNAL
A/D CONVERTER
10
APL CALCULATOR
20
LOOK-UP TABLE BLOCK
30
D/A CONVERTER
40
OUTPUT VIDEO SIGNAL

The present invention relates to a method and circuit for controlling the brightness and contrast of a video signal, and more particularly relates to a method and circuit in which the brightness and contrast of a video signal is adaptively controlled according to the average brightness level of a picture.

Natural illumination can have an extremely wide brightness range, and will have a vast range of contrast scales. The human eye adapts itself remarkably well for viewing naturally-lit objects and can easily perceive detail in shadows. Nevertheless, cameras or televisions are not easily adaptable to conditions of natural illumination. Colour cameras can be responsive to input light having a specific illumination range, but an electric output signal of the camera is limited to a range of, for example, 1 volt peak-to-peak. A conventional display apparatus often displays a poor, undesirable quality picture because its contrast range is extremely narrow.

To solve such a problem, US 4,152,720 and US 4,489,349 provide a "Contrast correction arrangement" and a "Video brightness control circuit" respectively. These Patents disclose methods for controlling contrast according to brightness adjustment. In the contrast correction apparatus of U.S. Patent No. 4,152,720, relative contrast enhancement is achieved by adjusting video signal input-output characteristics differently according to a user's externally applied control values for the camera. Figure 1 is a graph showing input-output characteristics used in a conventional contrast correction apparatus, which shows two characteristic curves y1 and y2 expressed as y1(x)=pow(x,0.5) and y2(x)=pow(x,2), where pow(x,2)=x^2. The prior art relating to Figure 1 improves the contrast based on the brightness control, and the contrast enhancement is, in fact, partially accomplished just as an additional effect of the brightness control. Thus, there causes a problem of a manual operation.

The "Video brightness control circuit" of U.S. Patent No. 4,489,349, controls the input-output characteristic according to the average picture level (APL) of a video input signal, such as previously described for US 4,152,720. However, adaptive operation according to the APL is different to that previously described whilst achieving a similar effect. Figure 2 shows the input-output characteristic of U.S. Patent No. 4,489,349, and the input-output characteristic will be given as

$$OUT = [nAPL \times y2(x)] + [(1 - nAPL) \times y1(x)]$$

where, the nAPL is a normalized average picture level, i.e., the average picture level of a video input signal, and y1(x) and y2(x) are input-output characteristic curves as shown in Figure 1. The relationship expresses the output OUT in which y1(x) and y2(x) are weighted to nAPL and 1-nAPL. For example, when the nAPL is 0.3, the output OUT becomes [0.3 X y2(x)]+[0.7 X y1(x)], and when the nAPL is 0.7, the output OUT becomes [0.7 X y2(x)]+[0.3 X y1(x)]. Accordingly, in the case that nAPL has a low value, such as 0.3, a total value of the APL is going up as the first characteristic curve y1 is weighted, whereas in the case that nAPL is 0.7, a total value of the APL is going down as the second characteristic curve y2 is weighted.

In Figure 2, variations are moved into the positive direction when the nAPL is less than 0.5, and they are moved into the negative direction when the nAPL is larger than 0.5, thereby the variation is added to an original signal. The closer the nAPL is to 0 or 1, the more the average picture level of the video input signal is varied, whereas the average picture level is varied only a little when the nAPL is around 0.5. This technique also controls the contrast using the average picture level relative to the brightness of pictures, but has a drawback that contrast efficiency drops due to making much of brightness process. Therefore, there is a disadvantage that an extremely dark picture, such as night scenery, provides a poor, undesirable picture due to brightness extension.

Therefore, with a view to solving or reducing the above problems, preferred embodiments of the present invention aim to provide an image enhancement method adaptive to a scene which divides a range of an average picture level in a video input signal into a plurality of areas, sets an individually different input-output characteristic to each of the divided areas, and controls the brightness and contrast of the video input signal according to the input-output characteristic of an area corresponding to the average picture level of a video input signal, thereby obtaining a picture with more advanced contrast than the conventional technique.

Another aim is to provide an image enhancement circuit in order to embody the above method.

According to a first aspect of the present invention, there is provided an image enhancement method which controls brightness and contrast of a video signal using an average brightness level, the method comprising the steps:

dividing a range of the average brightness level in a video input signal into a plurality of areas;

setting an individually different brightness correction characteristic to each of the divided areas;

calculating the average brightness level during a predetermined period with respect to the video input signal;

and controlling the brightness and contrast of the video input signal according to the brightness correction characteristic corresponding to the calculated average brightness level.

Preferably, said area dividing step comprises the step of dividing the average brightness level range of the video input signal into a plurality of areas according to efficiency of contrast enhancement.

Said areas are preferably composed of a first area in which the average brightness level corresponds to a dark scene, a second area of an intermediate average brightness level, a third area with an average brightness level between that of said first and second areas and a fourth area with an average brightness level above that of said second area, in the case that the range of average brightness level in the video input signal is between 0 and 1, said first area has average brightness level around "0" and said second area has average brightness level at or near "0.5".

Said brightness and contrast controlling step preferably comprises the step of outputting the video input signal as it is, in the case that the calculated average brightness level is within said first area.

Said brightness and contrast controlling step may comprise the step of correcting said level x of the video input signal by the following expression for contrast enhancement, in the case that the calculated average brightness level is within said second area:

OUT=y3(x)

y3(x)=pow(xL,2), y3(x)=pow(xH,0.5)

where, OUT is a corrected video signal, xL is a 0~0.5 period and xH is a 0.5~1 period.

Said brightness and contrast controlling step may comprise the step of correcting said level x of the video input signal by the following expression for contrast enhancement, in the case that the calculated average brightness level is within said second area:

OUT=amp X abs[m-abs(nAPL-m)] X y3(x)

y3(x)=pow(xL,2), y3(x)=pow(xH,0.5)

where, said OUT is a corrected video signal, amp is an amplification ratio, abs is an absolute value, nAPL is a normalized average picture level value, m is usually 0.5, xL is a 0~0.5 period, and xH is a 0.5~1 period.

Said brightness and contrast controlling step may comprise the step of correcting said level x of the video input signal by the following expression for contrast enhancement, in the case that the calculated average brightness level is within said second area:

OUT=amp1 X abs(m-abs(m-nAPL(1))) X y3l(x)

+amp2 X abs(m-abs(nAPL(h)-m)) X y3h(x)

y3l(x)=pow(xL,2), y3h(x)=pow(xH,0.5)

where, said OUT is a corrected video signal, m is usually 0.5, amp1 and amp2 are amplification ratios above and below "m", abs is an absolute value, nAPL(l) and nAPL(h) are normalized average picture level values obtained by respectively calculating the video input signal above and below "m", xL is a 0~0.5 period, and xH is a 0.5~1 period.

Said brightness and contrast controlling step may comprise the step of correcting said level x of the video input signal by the following expression for contrast enhancement, in the case that the calculated average brightness level is within said third area:

OUT=abs(abs(p-q)/p) X y1(x), y1(x)=pow(x,0.5)

p=a_area-period/2, q=abs(a_area_center-nAPL)

where, OUT is a corrected video signal, abs is an absolute value, a_area-period represents a period of an area "a", a_area_center is a central value of the "a" area, nAPL is a normalized APL value.

Said brightness and contrast controlling step may comprise the step of correcting said level x of the video input signal by the following expression for contrast enhancement, in the case that the calculated average brightness level is within said first area or said third area:

OUT=(0.5-nAPL) X y1(x), y1(x)=pow(x,0.5)

where, said OUT is a corrected video signal, and nAPL is a normalized APL value.

Said brightness and contrast controlling step may comprise the step of correcting said level x of the video input signal by the following expression for contrast enhancement, in the case that the calculated average brightness level is within said fourth area:

OUT=amp X abs(nAPL-m) X y2(x), y2(x)=pow(x,2)

where, said OUT is a corrected video signal, m is commonly 0.5, amp is an amplification ratio, abs is an absolute value, nAPL is a normalized APL value.

According to a second aspect of the present invention there is by provided an image enhancement circuit which controls and outputs the brightness and contrast of a video signal using an average brightness level, the circuit comprising:

calculating means for calculating the average brightness level during a predetermined period with respect to a video signal to be input through an input terminal;

and controlling means for controlling the brightness and contrast of the video input signal according to brightness correction characteristics corresponding to the calculated average brightness level, in which the range of the average brightness level in the video input signal is divided into a plurality of areas, and a plurality

of input-output characteristic curves are provided so that the brightness and contrast of the video input signal is differently corrected for respective areas.

Said brightness and contrast controlling means preferably stores each of brightness correction characteristics corresponding to said average brightness level as format of a look-up table which is composed of a video output signal corresponding to a video input signal.

Said brightness and contrast controlling means corrects the brightness and contrast of a video signal to be input following the video input signal which is used in calculating of the average brightness level.

The circuit may further comprise a delay unit, located before said brightness and contrast controlling means, for delaying and outputting the video input signal supplied through an input so that the brightness and contrast of the video input signal used in calculating of the average brightness level can be controlled.

The circuit may further comprise an amplifier which amplifies said video input signal with an amplification ratio which is varied according to the average brightness level calculated by said average brightness level calculating means, and outputs the amplified signal to said brightness and contrast controlling means.

Said amplifier preferably amplifies said video input signal so that the slope of an input-output characteristic curve becomes low, in the case that the calculated value of said average brightness level is near "1", while it amplifies said video input signal so that the slope of an input-output characteristic curve becomes high, in the case that the calculated value of said average brightness level is close to "0".

Said average brightness level calculating means may comprise a low-pass filter for counting a value of the average brightness level by passing through only low components of the video input signal, and then for outputting corresponding voltage; and

a decoder for outputting a control signal to control said brightness and contrast controlling means according to said voltage supplied from said low-pass filter.

For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings, in which:

Figure 3 is a graph showing input-output characteristics used in accordance with embodiments of the present invention;

Figure 4 is a graph showing brightness correction characteristics of an image enhancement circuit in accordance with embodiments of the present invention;

Figure 5 is a block diagram for illustrating a first embodiment of an image enhancement circuit;

Figure 6 is a block diagram for illustrating a second embodiment of an image enhancement circuit;

Figure 7 is a graph showing input-output characteristic curves of an amplifier of Figure 6; and

Figure 8 is a block diagram for illustrating a third embodiment of an image enhancement circuit.

Preferred embodiments of the present invention will be described below in more detail with reference to the accompanying drawings.

Figure 3 is a graph showing input-output characteristics used in the present invention. In Figure 3, two curves y1, y2 are the same as the input-output characteristic curves of Figure 1, and an S-typed curve represents an input-output characteristic curve added so as to adjust brightness and contrast using an average picture level. A first characteristic curve y1 causes a large increase in brightness of the input signal and a relative contrast enhancement effect of low level values. A second characteristic curve y2 results in a large decrease in brightness of the input signal and a relative contrast enhancement effect of high level values. A third characteristic curve y3 effects a large increase in contrast.

Figure 4 shows a graph illustrating the correction characteristic of brightness and contrast in the image enhancement method in accordance with the present invention. The characteristic curve of Figure 4 illustrates that contrast adjustment using the input-output characteristic curves y1, y2 and y3 is performed at the divided areas on the nAPL, respectively. The invention divides a range of the average picture level in the video input signal into four areas, and allows for a respective brightness correction characteristic for each area which is determined by the nAPL of the video input signal, input-output characteristic curves of Figure 3 and applies differently weighted values for each area. The video input signal is adjusted in brightness and contrast by the brightness correction characteristics. As a result, a video signal with enhanced contrast is obtained. The input-output characteristic curves for an embodiment of the present invention will be expressed as:

$y1(x)=pow(x,0.5)$ $\qquad$ $y2(x)=pow(x,2)$

$y3L(x)=pow(xL,2)$ $\qquad$ $y3H(x)=pow(xH,0.5)$

where, xL is in the range of 0-0.5 and xH is in the range of 0.5~1. In the above equations of pow(x,0.5) and pow(x,2), it is not necessary to limit exponential parts to 0.5 or 2, and an exponential value can be substituted by other values, if necessary.

As shown in Figure 4, the present invention may be divided into four areas. Boundaries of these areas can be properly selected according to the brightness and contrast correction. In figure 4, the rest has the nAPL

smaller than an area "a" without any area remark. An explanation concerning the input-output characteristic curves which are employed in the contrast enhancement of each area will be given as follows. For brightness and contrast corrections, when the nAPL value is within an area "a", the first characteristic curve y1 is selected. When the nAPL value is within an area "b" the third characteristic curve y3 is selected, and when the nAPL value is within an area "c" the second characteristic curve y2 is selected.

Using the input-output characteristic curves of Figure 3, further expressions will be described for use in the contrast adjustment according to areas as shown in Figure 4. nAPL values within the "a" area are nAPL values obtained by the darkest portion of a picture. In the case of this area, the level of an input signal is equal to that of an output signal. Thus, the brightness of the input and output signals is the same to prevent undesirable pictures.

For example, the output signal OUT of the "a" area will be given as the following expression (1):

$$OUT = |(p-q)/p| \times y1(x) \quad (1)$$

where, p is defined as (an interval of "a" area)/2, and Q is |a central value of "a" area-nAPL|. The central value of "a" area may be expressed as "d" in Figure 4. The above expression (1) shows that a weighted value to the first characteristic curve y1 is determined by a half of the "a" area interval, and an absolute value to difference between the central value of the "a" area and the nAPL value. Accordingly, the output signal OUT becomes y1(x) when the nAPL value is in the middle of the "a" area, and the OUT becomes c X y1(x) by means of a normalized form of $c=|p-q|/p<1$ when the nAPL value is far from the middle of the "a" area. The characteristic curve of the expression (1) is shown as continuing into the "b" area of Figure 4. The characteristic of the expression (1) smoothly connects characteristics of the areas "a" and "b", together with a "S" characteristic of the "b" area. The input-output characteristic given by the expression (1) represents a general increase in variations from the left to right, the central value "d" of the "a" area is at the maximum in the variations of the input-output characteristic. In area "b", since the nAPL value of the input signal is close to 0.5, the characteristic curve "S" usually contributes to the contrast enhancement. Thus, the output signal OUT above and below on the basis of the nAPL value being 0.5, may be obtained by the expressions (2) and (3):

$$OUT = y3(x) \quad (2)$$

$$OUT = amp \times |m - |nAPL - m|| \times y3(x) \quad (3)$$

where, m is usually 0.5 and amp is an amplification ratio. The output signal of further advanced form is adaptably calculated according to the nAPL value given by

$$OUT = amp1 \times |m - |m - nAPL(l)|| \times y3yl(x) + amp2 \times |m - |nAPL(h) - m|| \times y3h(x) \quad (4)$$

where, nAPL(*l*) and nAPL(*h*) means the nAPL value calculated by respectively classifying the video input signal having levels above and below "m", and y3*l* and y3*h* shows that the third characteristic curve y3 is divided from "m". The "c" area is obtained by the following expression (5) that is dependent on the second characteristic curve y2 according to a value of nAPL-m:

$$OUT = amp \times |nAPL - m| \times y2(x) \quad (5)$$

The input signal is corrected by the expressions of the corresponding area with the calculated nAPL value. In Figure 4, the reason why the characteristic curve within the "c" area exists in the "b" area is to make the characteristic variations between the "b" and "c" areas smooth. On the other hand, the brightness correction characteristics of the "a" area and the rest can be calculated by

$$OUT = (0.5 - nAPL) \times y1(x) \quad (6)$$

Figure 5 is a block diagram for illustrating a first embodiment of the image enhancement circuit in accordance with the present invention. As shown, an analog to digital converter 10 converts an analog video signal to be input into a digital video signal, and to an output of which an average picture level (APL) calculator 20 and a look-up table block 30 are connected respectively. The APL calculator 20 receives the video signal output from the A/D converter 10 and calculates a nAPL value. The look-up table block 30 corrects and outputs the output signal from the A/D converter 10 according to the output APL value from the APL calculator 20. The output signal of the look-up table block 30 is supplied to a digital to analog converter 40 and is converted into an analog video signal.

The video signal input to the image enhancement circuit of Figure 5 is converted into a digital signal by the A/D converter 10, and then the converted digital signal is supplied to the APL calculator 20 and the look-up table block 30, respectively. The APL calculator 20 calculates a nAPL value of the video input signal with respect to the real interval of a video signal during one frame period or a plurality of frame periods. At this time, the nAPL value is continuously reproduced for each input frame. The look-up table block 30 stores the brightness correction characteristics, which relates to the four areas in the form of look-up table in which the video input signal is designated as address, and corrects and outputs the brightness of the video input signal according to the level of the video input signal and the corresponding nAPL value. Therefore, when the nAPL value is supplied from the APL calculator 20, the look-up table block 30 judges a corresponding area of the

input value, and corrects and outputs the Input digital video signal according to the brightness correction characteristic of the corresponding area. One of common skill in the art can construct the look-up table block 30 as many as areas, or can employ various methods based on the expressions corresponding to each area. The digital data read out from the look-up table block 30 is provided to the D/A converter 40, and is converted into an analog video signal. Here, the output video signal of the D/A converter 40 is corrected in brightness and contrast. In the circuit of Figure 5, although a frame with the calculated nAPL value is different from a frame that is actually input to the look-up table block 30, there is generally not any problem since video signals between adjacent frames are varied smoothly. However, in the case than an abrupt transition of the video signal, such as a scene change happens, or that brightness correction for the video signal of the calculated nAPL value may be performed, a delay element is connected between A/D converter 10 and look-up table block 30. The delay element delays the video signal output from the A/D converter 10 during the period in which the nAPL value is calculated.

Figure 6 is a block diagram for illustrating a second embodiment of an image enhancement circuit. Blocks of the image enhancement circuit of Figure 6 which have the same construction and function as in Figure 5 are designated with the same reference numerals. An amplifier 50 is further added between A/D converter 10 and look-up table block 30. The amplifier 50 amplifies the video signal output from the A/D converter 10 with a variable amplification ratio which is determined by the nAPL value provided from the APL calculator 20, and outputs the amplified signal to the look-up table block 30.

Figure 7 is a graph showing input-output characteristic curves by the amplifier 50. The amplifier 50 changes the amplification ratio of the video input signal into the direction "s3" when the nAPL value supplied from the APL calculator 20 is at or near "1", and it amplifies the video input signal into the direction "s2" if the nAPL value is not near "1". This intention is to control the level condition in a scene which is brightly lit and thereby to improve correction efficiency compared with the apparatus of Figure 5.

Figure 8 is a block diagram for illustrating a third embodiment of an image enhancement circuit in accordance with the present invention. Blocks of the image enhancement circuit of Figure 8 which have the same construction and function as in Figure 5 are designated with the same reference numerals. However, the APL calculator 20 of Figure 5 is substituted by a low-pass filter (LPF) 60 and a decoder 70. The LPF 60 calculates an approximate nAPL value in case that a time constant is composed of a great filter, and then roughly counts a value of portions not real pictures, such as a horizontal synchronizing period and a vertical blanking period, and subtracts the calculated value from the nAPL value, thereby providing the correction.

The LPF 60 calculates a nAPL value of the video input signal with respect to the real interval of a video signal during one frame period or a plurality of frame periods. The calculated nAPL value is output to the decoder 70 as voltage. The decoder 70 outputs a signal to control the look-up table block 30 by the voltage supplied from the LPF 60.

As described above, adaptive correction of the brightness is provided by individually permitting different input-output characteristics according to values of average brightness level of a video input signal, and thereby obtaining a contrast enhanced video signal. Even a dimly-lit picture may be naturally displayed by preventing an abrupt variation in brightness, and pictures enhanced in brightness and contrast are provided by adjusting only the contrast at a particular nAPL range. Furthermore, the correction efficiency of brightness and contrast is improved by means of controlling an amplification ratio of the video signal.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. An image enhancement method adaptive to a scene which controls brightness and contrast of a video signal using an average brightness level, the method comprising the steps:
   dividing a range of the average brightness level in a video input signal into a plurality of areas;
   setting an individually different brightness correction characteristic to each of said divided areas;
   calculating the average brightness level during a predetermined period with respect to the video input signal; and
   controlling the brightness and contrast of the video input signal according to the brightness correction characteristic corresponding to said calculated average brightness level.

2. The image enhancement method as claimed in claim 1, wherein said area dividing step comprises the step of dividing the average brightness level range of the video input signal into a plurality of areas according to efficiency of contrast enhancement.

3. The image enhancement method as claimed in claim 1 or 2, wherein said areas are composed of a first area in which the average brightness level corresponds to a dark scene, a second area of an intermediate average brightness level, a third area with an average brightness level between that of said first and second areas and a fourth area with an average brightness level above that of said second area, in the case that the range of average brightness level in the video input signal is between 0 and 1, said first area has average brightness level around "0" and said second area has average brightness level at or near "0.5".

4. The image enhancement method as claimed in any of claims 1, 2 or 3, wherein said brightness and contrast controlling step comprises the step of outputting the video input signal as it is, in the case that the calculated average brightness level is within said first area.

5. The image enhancement method as claimed in claim 3 or claim 4 as dependant upon claim 3, wherein said brightness and contrast controlling step comprises the step of correcting said level x of the video input signal by the following expression for contrast enhancement, in the case that the calculated average brightness level is within said second area:
   OUT=y3(x)
   y3(x)=pow(xL,2), y3(x)=pow(xH,0.5)
   where, OUT is a corrected video signal, xL is a 0~0.5 period and xH is a 0.5~1 period.

6. The image enhancement method as claimed in claim 3 or claims 4 or 5 as dependent upon claim 3, wherein said brightness and contrast controlling step comprises the step of correcting said level x of the video input signal by the following expression for contrast enhancement, in the case that the calculated average brightness level is within said second area:
   OUT=amp X abs[m-abs(nAPL-m)] X y3(x)
   y3(x)=pow(xL,2), y3(x)=pow(xH,0.5)
   where, said OUT is a corrected video signal, amp is an amplification ratio, abs is an absolute value, nAPL is a normalized average picture level value, m is usually 0.5, xL is a 0~0.5 period, and xH is a 0.5~1 period.

7. The image enhancement method as claimed in claim 3 or any of claims 4 to 6 as dependent upon claim 3, wherein said brightness and contrast controlling step comprises the step of correcting said level x of the video input signal by the following expression for contrast enhancement, in the case that the calculated average brightness level is within said second area:
   OUT=amp1 X abs(m-abs(m-nAPL(l))) X y3l(x)
   +amp2 X abs(m-abs(nAPL(h)-m)) X y3h(x)
   y3l(x)=pow(xL,2); y3h(x)=pow(xH,0.5)
   where, said OUT is a corrected video signal, m is usually 0.5, amp1 and amp2 are amplification ratios above and below "m", abs is an absolute value, nAPL(l) and nAPL(h) are normalized average picture level values obtained by respectively calculating the video input signal above and below "m", xL is a 0~0.5 period, and xH is a 0.5~1 period.

8. The image enhancement method as claimed in claim 3 or any of claims 4 to 7 as dependent upon claim 3, wherein said brightness and contrast controlling step comprises the step of correcting said level x of the video input signal by the following expression for contrast enhancement, in the case that the calculated

average brightness level is within said third area:

$OUT=abs(abs(p-q)/p) \times y1(x), \quad y1(x)=pow(x,0.5)$

$p=a\_area\text{-}period/2, \quad q=abs(a\_area\_center-nAPL)$

where, OUT is a corrected video signal, abs is an absolute value, a_area-period represents a period of an area "a", a_area_center is a central value of the "a" area, nAPL is a normalized APL value.

9. The image enhancement method as claimed in claim 3 or any of claims 4 to 8 as dependent upon claim 3, wherein said brightness and contrast controlling step comprises the step of correcting said level x of the video input signal by the following expression for contrast enhancement, in the case that the calculated average brightness level is within said first area or said third area:

$OUT=(0.5-nAPL) \times y1(x), \quad y1(x)=pow(x,0.5)$

where, said OUT is a corrected video signal, and nAPL is a normalized APL value.

10. The image enhancement method as claimed in claim 3 or any of claims 4 to 9 as dependent upon claim 3, wherein said brightness and contrast controlling step comprises the step of correcting said level x of the video input signal by the following expression for contrast enhancement, in the case that the calculated average brightness level is within said fourth area:

$OUT=amp \times abs(nAPL-m) \times y2(x), \quad y2(x)=pow(x,2)$

where, said OUT is a corrected video signal, m is commonly 0.5, amp is an amplification ratio, abs is an absolute value, nAPL is a normalized APL value.

11. An image enhancement circuit adaptive to a scene which controls and outputs the brightness and contrast of a video signal using an average brightness level, the circuit comprising:

calculating means (20) for calculating the average brightness level during a predetermined period with respect to a video signal to be input through an input terminal; and

controlling means (30) for controlling the brightness and contrast of the video input signal according to brightness correction characteristics corresponding to said calculated average brightness level, in which the range of said average brightness level in said video input signal is divided into a plurality of areas, and a plurality of input-output characteristic curves are provided so that the brightness and contrast of said video input signal is differently corrected for respective areas.

12. The image enhancement circuit as claimed in claim 11, wherein said brightness and contrast controlling means (30) stores each of brightness correction characteristics corresponding to said average brightness level as format of a look-up table which is composed of a video output signal corresponding to a video input signal.

13. The image enhancement circuit as claimed in claim 11 or 12, wherein said brightness and contrast controlling means (30) corrects the brightness and contrast of a video signal to be input following the video input signal which is used in calculating of the average brightness level.

14. The image enhancement circuit as claimed in claim 11, 12 or 13, further comprising a delay unit, located before said brightness and contrast controlling means (30), for delaying and outputting the video input signal supplied through an input so that the brightness and contrast of the video input signal used in calculating of the average brightness level can be controlled.

15. The image enhancement circuit as claimed in any of claims 11 to 14, further comprising an amplifier (50) which amplifies said video input signal with an amplification ratio which is varied according to the average brightness level calculated by said average brightness level calculating means (20), and outputs the amplified signal to said brightness and contrast controlling means (30).

16. The image enhancement circuit as claimed in claim 15, wherein said amplifier (50) amplifies said video input signal so that the slope of an input-output characteristic curve becomes low, in the case that the calculated value of said average brightness level is near "1", while it amplifies said video input signal so that the slope of an input-output characteristic curve becomes high, in the case that the calculated value of said average brightness level is close to "0".

17. The image enhancement circuit as claimed in any of claims 11 to 16, wherein said average brightness level calculating means (20) comprises a low-pass filter (60) for counting a value of the average brightness level by passing through only low components of the video input signal, and then for outputting corre-

sponding voltage; and

a decoder (70) for outputting a control signal to control said brightness and contrast controlling means according to said voltage supplied from said low-pass filter.

FIG. 1 (PRIOR ART)

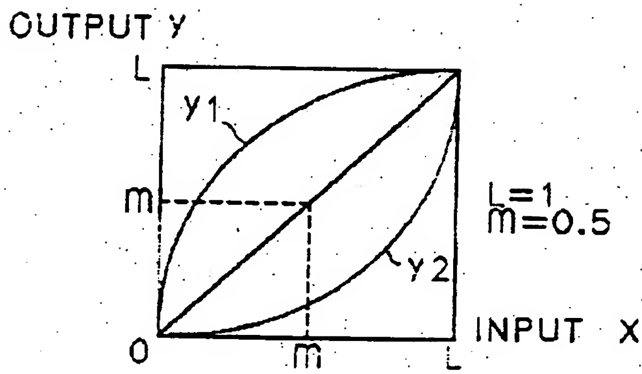


FIG. 2 (PRIOR ART)

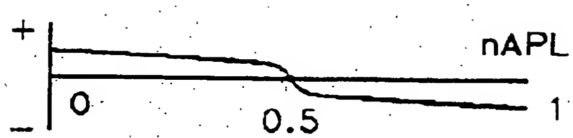


FIG. 3

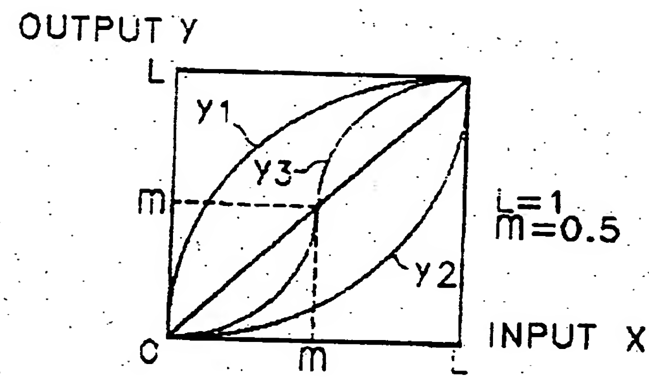

OUTPUT Y
L
y1
y3
m
y2
L=1
m=0.5
O
m
L
INPUT X

FIG. 4

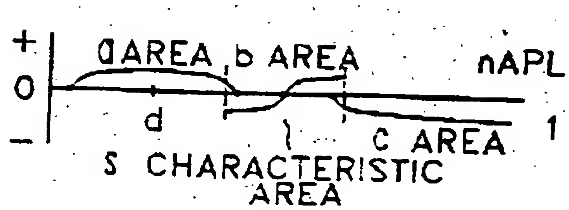

+
0
−
a AREA
b AREA
nAPL
d
c AREA
1
S CHARACTERISTIC AREA

FIG. 5

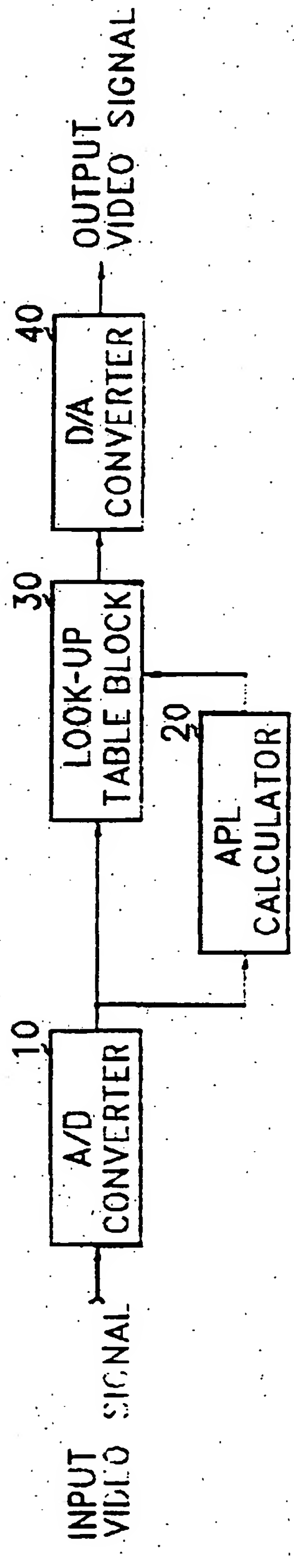

INPUT VIDEO SIGNAL
A/D CONVERTER
10
APL CALCULATOR
20
LOOK-UP TABLE BLOCK
30
D/A CONVERTER
40
OUTPUT VIDEO SIGNAL

FIG. 6

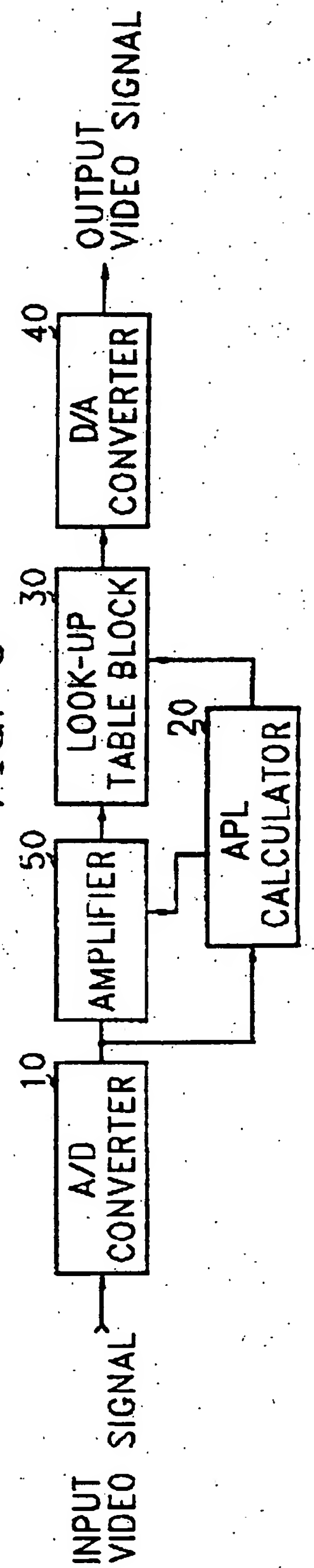

INPUT VIDEO SIGNAL
A/D CONVERTER
10
AMPLIFIER
50
APL CALCULATOR
20
LOOK-UP TABLE BLOCK
30
D/A CONVERTER
40
OUTPUT VIDEO SIGNAL

FIG. 7

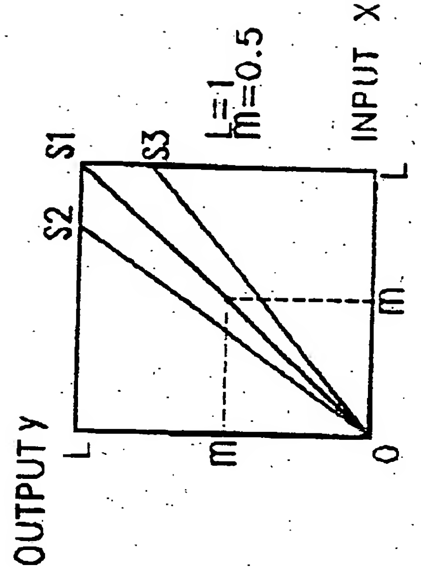
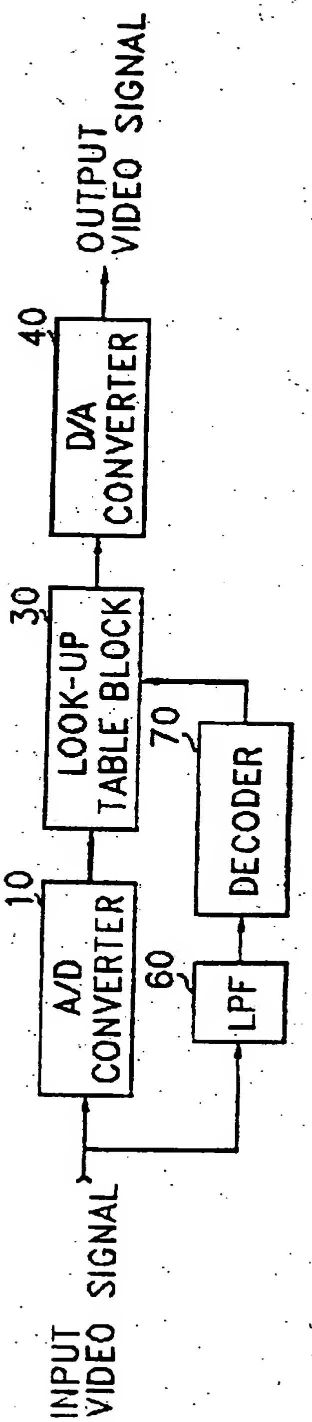

OUTPUT Y
L
m
0
m
L
INPUT X
S1
S2
S3
L=1
m=0.5

FIG. 8


INPUT VIDEO SIGNAL
10
A/D CONVERTER
60
LPF
DECODER
70
30
LOOK-UP TABLE BLOCK
40
D/A CONVERTER
OUTPUT VIDEO SIGNAL